Sunflower Breeding Achievements and Challenges

Breed for Grower Needs

China, August 2018

Classification: Public

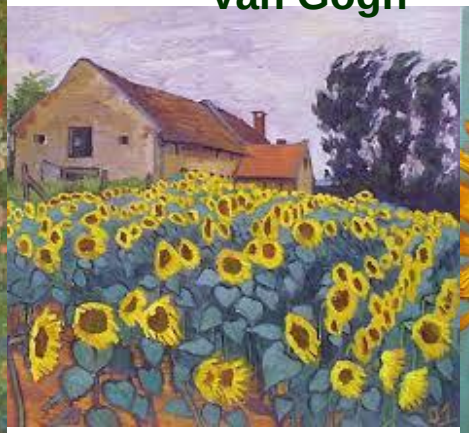
Sunflower - Inspiration for Painters

Van Dyck

Van Gogh

Paul Gauguin

Gustav Klimt



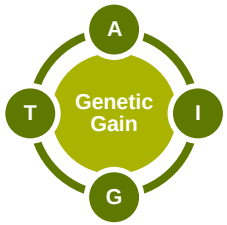
Vitali Komarov

Kim Blair

Marcel Caram

And Furniture ....

Major historical events impacting sunflower breeding



1920's: Oil changed from 30% to 50%

1920's-1970's: Public breeding era

1920 1940 1960 1980 2000 2020

- 1974: 1st CMS hybrids
- 1978: 1st mildew-resistant hybrid
- 1996: Herbicide tolerance discovered
- 2003: First HT hybrid launched
- 2012: Discovery of AIR mutation
- 2012: CRISPR-Cas9
- 2008: Discovery of CLHA-Plus mutation
- 1967: Discovery of CMS and Restorer system (Rf)
- 1976: HO mutation discovered
- 1990's: genetic markers were first used in sunflower breeding

Private industry began investing more in sunflower breeding, acquiring most of their germplasm from the public sector

Companies recognize the value of genetic marker technology

Germplasm base

1912-1970

- Sunflower breeding effort limited to public sector

Rich Genus

- 14 annual species
- 37 perennial species
- Diverse germplasm base of public breeding programs

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Sunflower Variability

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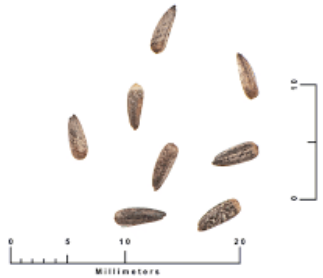
Sunflower seeds variability



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Variability in plant height

Key Breeding Targets

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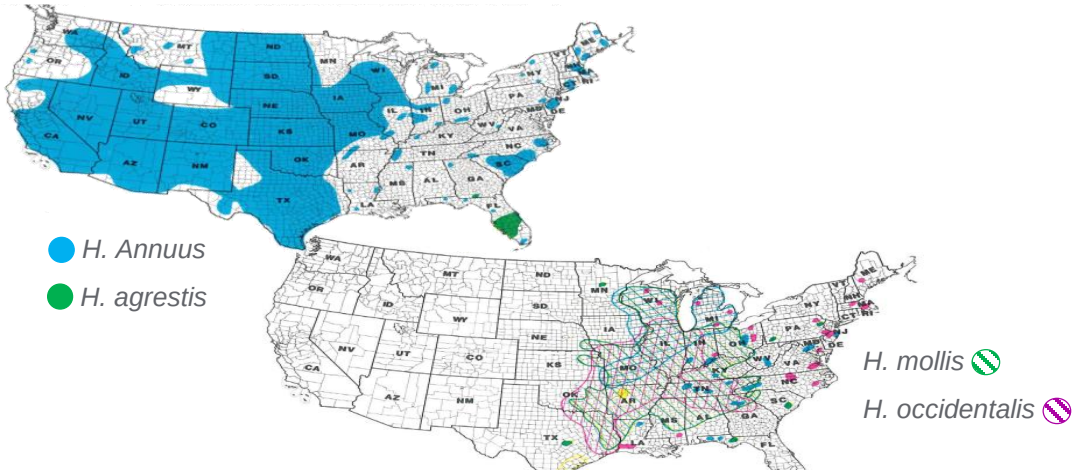
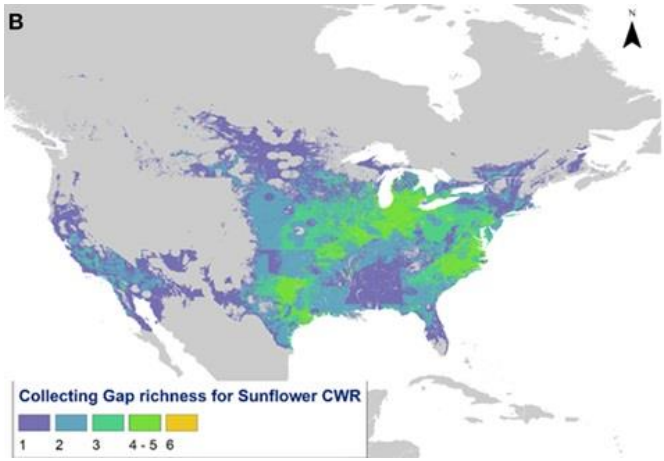
Trait discovery and development

The *Helianthus* genus is a rich of many species which gave us in the past lots of good opportunities in different breeding programs



Distribution of Helianthus annus L. and Helianthus mollis.
Sunflower species of the United States.

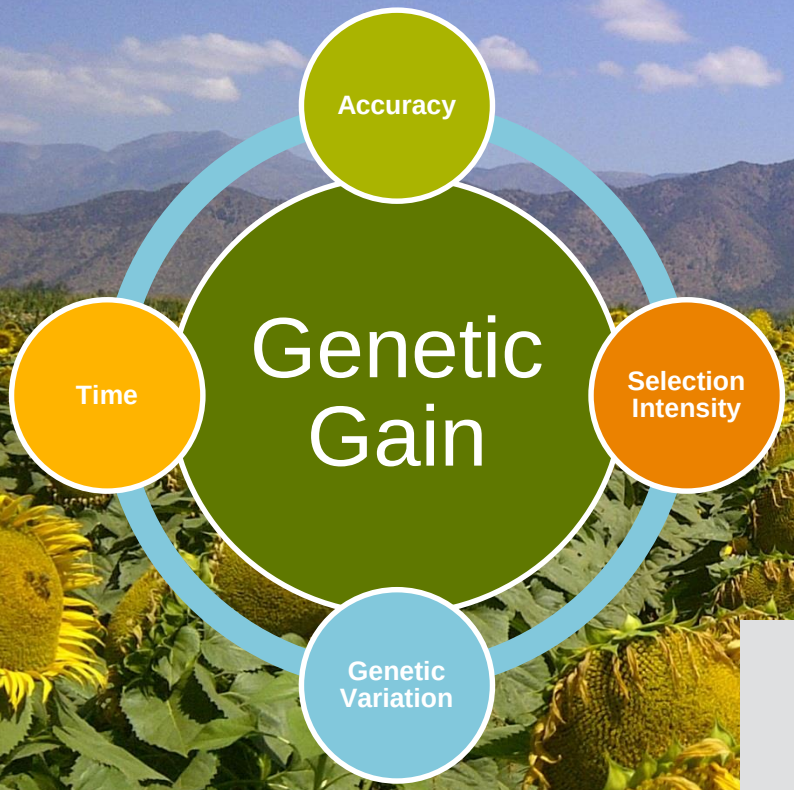
Rogers et al. 1982



Predicted distribution maps of hotspots for further collecting of high priority taxa (Gap analysis, based on 36 *Helianthus* taxa.
(CRW: Crop Wild relatives)

Kantar *et al.* 2015, Front. Plant Sci.

A breeding program efficiency is driven by the Genetic Gain



Cost per unit of genetic gain drives the cost-efficiency of a breeding program

Investment optimization of genetic improvement = $\frac{\text{Genetic gain}}{\text{Cost}}$

Optimization mathematics will provide:

- **estimates of maximum genetic gain per dollar invested**

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Need to sustain sunflower yield across territories

10 years

Reducing by at least 2 years

1. Shortening a breeding cycle
2. DH, GS and MARS development will be major driver to improve genetic gain
3. Molecular genetics and associated technologies will continue to be key in the discovery and understanding of novel traits

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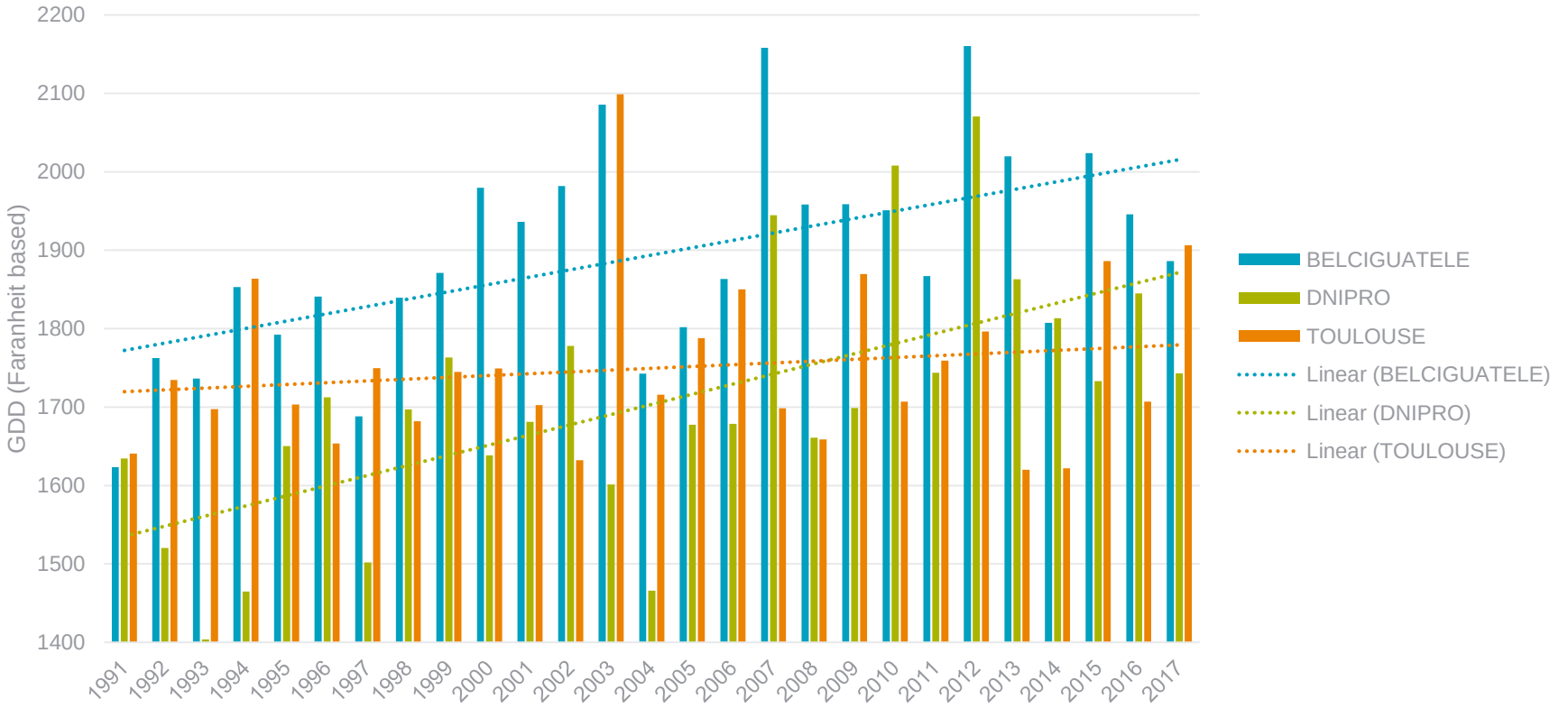
accumulated heat unit calculation in sunflower vegetation period (04.15 – 08.31 (140 days)

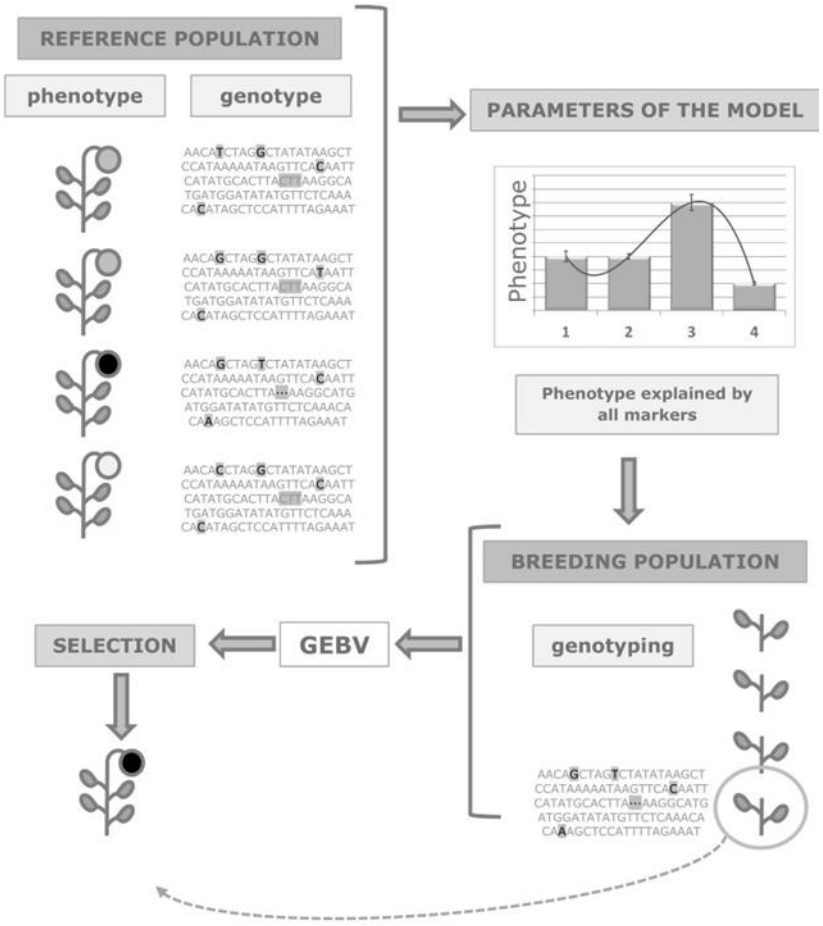
Daily Sunflower GDD (°C) = Daily Average Temperature °C – 6.7 °C

Calculation methods: The Daily Average Temp (°C) = (Daily Max Temp °C + Daily Min Temp °C) / 2

If the daily Max and/or Min Temp < 6.7 °C (44 °F) it's set equal to 6.7 °C (44 °F).



Marker Assisted Recurrent Selection (MARS) and Genome Wide Selection (GWS) allows to better predict breeding value for genetic gain to increase chance of success and decrease invested time and money vs classical breeding



(A.M. Pérez-de-Castro et al. 2012).

- Marker Assisted Recurrent Selection (**MARS**) and Genome Wide Selection (**GWS**) will allow breeders to better predict the breeding value, as manifest by genetic gain, of crosses and breeding programs.
- **GWS -** The model predicts the phenotype of plants in a breeding population on the basis of the genotyping results: this is the genomic estimated genetic breeding value (GEBV), used to select the desired phenotypes

Conclusions

- Stay competitive like crop
- Sunflower today is very market segmented field crop which required more resources and efficiency in breeding
- Genetic gain
- Further development of the MARS and Genome-based selection
- Genomic information is no longer a bottleneck or a limiting factor in sunflower research
- Climate change and adaptation of sunflower to changes
- Development of new technology – e.g. genome editing
- Increase importance of joint programs in collaboration between private and public institutions